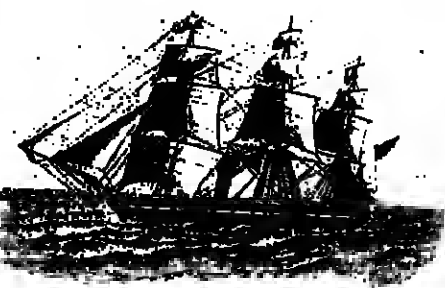


The Oceanography Report



The Oceanography Report
The focal point for physical, chemical, geological, and biological oceanographers.

Editor: Arnold L. Gordon, Lamont-Doherty Geological Observatory, Palisades, NY 10961 (telephone 914-359-2900, ext. 925).

FGGE Buoys: 5 Years Later

John Garrett

During the final months of 1978 and early 1979 large numbers of small drifting buoys were launched all over the southern ocean in preparation for the First Global Atmospheric Research Program (GARP) Global Experiment. At the time, those of us who had been involved in the preceding years of planning and development were mainly occupied with immediate questions—Would the Argos satellite tracking system work? Would the buoys survive long enough to form a useful array—but our long-term use of the data for oceanographic research. The buoy system worked better than we expected and returned a major data set on the surface currents and temperatures of the southern ocean. Now, 5 years later, it seems timely to review our experience. I will examine what we learned about the potential of drifting buoys and how our experience may help us to plan future large-scale observing systems of all types.

History

By the mid 1980's it was recognized that the absence of a global atmospheric data set would ultimately be a limiting factor in determining and exploiting the predictability of atmospheric motions. This recognition led the Joint Organizing Committee on GARP to plan for a global meteorological experiment, which became known as the First GARP Global Experiment (FGGE). One area of great concern was the southern hemisphere, where the large expanse of ocean led to a very low density of conventional meteorological observations. Although satellite technology was still fairly new, the idea of using orbital satellites to track automatic platforms and collect their data had already been proposed, and systems using inexpensive transmitters were on the drawing boards in the United States and France. Although the initial objectives of both the French Eole system and the U.S. Nimbus RAMS system were the tracking of constant pressure balloons, it was quickly obvious that the light, low power balloon transmitters could be used on small floating buoys. This gave rise to the idea that a system consisting of free-drifting buoys measuring surface pressures together with constant-pressure balloons giving wind data at one or more levels might provide the required information from the southern hemisphere.

The French balloon group stimulated buoy activity by making some balloons and balloon transmitters available to oceanographers in early 1972. Although the first balloon transmitters proved too fragile to survive long at sea, oceanographers were not slow to see the possibilities of a system in which a buoy powered by 20 kg of batteries could be followed for up to a year. Enthusiasm for the Nimbus RAMS system, with its comparatively low-cost transmitters, led to the initiation of drifting buoy programs in Australia, Canada, France, South Africa, and the United States. Thus in 1974, when planning began in earnest for the FGGE system, there was some experience with satellite-tracked drifting buoys which, combined with parallel experience with small meteorological buoys, suggested that the system was feasible. However, there were serious fears that barometric pressure observations could not be made to the required accuracy by any automatic station unattended for a year, even if it were mounted on a small buoy. It was also clear that achievement of buoy lifetimes long enough to make the project practical would tax the limits of our engineering capabilities. Nevertheless, optimism prevailed, development programs were established in several countries, with early positive results, and planning proceeded.

One element beyond the control of the buoy group gave rise to great concern: the use of a new, untried satellite tracking sys-

tem, which was scheduled to replace the Nimbus RAMS system only a few months before the actual experiment was to begin. Although the transmitter design would be similar to those in use, any change seemed likely to adversely affect its reliability, which was expected to be the factor limiting buoy life. Also there was the risk that the new system might not work at all. The planned launch date of the new system was too late to permit any major redesign or to correct faults in the buoys. However, this risk had to be accepted, although we were very unhappy when the satellite launching was delayed until only days before the first buoy deployments, and after many of the buoys were already on ships at sea. It was a great relief when the Argos system worked nearly perfectly from the moment it was turned on!

During the preliminary planning process scientists with experience in southern hemisphere oceanography were invited to participate. Several attended early meetings, but their interest seemed to diminish when it was found that the limited number of buoys available would result in separations on the order of 1000 km to cover the area for which meteorological data was required. For some reason the idea of supplementing meteorological funding with oceanographic funding to increase the density of the array in selected areas was never seriously proposed, although hindsight suggests that this would have been a valuable thing to have done. However, the oceanographic priorities of the day were elsewhere.

The organizational framework for the buoy system was based on national programs, which were coordinated to ensure that the measurement specifications were met and that the buoy deployments were optimized to produce the most nearly uniform possible array. The committee held only five formal meetings, one of which was a critical review at the end of the experiment, but small, full-time centers were set up to coordinate the deployment and to prepare the delayed time data set.

The 360 buoys were launched by a collection of vessels, including research ships, Antarctic supply vessels, military vessels, commercial ships, and even a longboat from Pitcairn Island. Aircraft were also successfully used to deploy buoys in the Arctic and in the southern ocean. The deployment plan was designed to produce optimal coverage (1000-km-grid) during the special observing periods of January-February and June-July 1979. To allow for the unknown buoy lifetime, the array was deployed gradually between November 1978 and July 1979. The planning was remarkably successful, as shown by the fact that 70% of the ocean between 20°S and 65°S was within 500 km of a working buoy from April until September 1979.

Data were collected and distributed from the buoy array between November 1978 and May 1981, although the number of buoys declined steadily after June 1979, when there were 286 transmitting from the southern ocean. These data were distributed within a few hours for use in operational meteorology and oceanography. They were also archived for future research use, after a quality control process based on comments received from the operational data users. The archived data for the FGGE operational year (November 1978–December 1979) have been available since July 1981 and those for the following year since January 1982 [Garrett, 1980]. A companion report which reviews the performance of every buoy is also available to assist in decisions regarding data quality [World Meteorological Organization, 1980]. Temperature maps produced using this real time data set were distributed during the operational year and have been compiled into a report [Keeley and Taylor, 1982].

Oceanographic Results

Within a few months, the real time data that appeared in several publications showed that the buoy data were in general agreement with conventional thinking on the circulation of the Southern Ocean [Kort, 1981; Meincke, 1980] while others used it for regional studies [Lafont et al., 1981]. Although some preliminary reports based on the full, archived data set have appeared [Garrett, 1981], more complete studies have been delayed by the sheer volume of data. A few groups are currently working on different problems using the data, and publications are to be expected in the next few months.

My own work suggests that the oceanographic potential of the buoy data is very high. Maps of mean buoy drift velocities averaged over 300-km cells resemble established ideas of the general circulation and show significant correlation with surface currents computed from dynamic heights. Linear regression coefficients between buoy speeds and currents computed from dynamic heights have the values that would be expected from the computed profiles of baroclinic shear. However, there are important differences between the buoy mean currents and those deduced from density data related to the fact that the buoy data were collected

over a considerable period of time while a typical oceanographic cruise produces a more or less instantaneous view. In many respects the most interesting aspect of the buoy data is in the distribution and magnitude of the variability of the drifts. Maps of mesoscale variability show maxima associated with the return flows of western boundary currents, and with places where the Antarctic Circumpolar Current crosses meridional ridges. This distribution agrees reasonably well with maps of "eddy kinetic energy" obtained from ship drifts and satellite altimetry, and also permits other types of analysis to examine the nature of the motions involved. In most areas the variance of the currents is large enough that the statistical reliability of the estimate of the mean is small, particularly for the north-south component, which raises some important questions for programs trying to measure meridional transports. The mesoscale velocities are nearly isotropic, i.e., meridional and zonal components contain nearly equal energies. The spectra of the buoy velocities between scales of 300 km and 50 km show a power-law dependence approximately proportional to the $-5/3$ power.

It seems obvious that the buoy motions would be directly affected by the wind, but it turns out to be difficult to isolate such effects, suggesting that they do not play a major role in controlling buoy drifts. In some regions the buoy tracks are highly reproducible over periods of several months. The mean and eddy kinetic energy fields contain regions of comparatively low values which are smaller than variations in the average wind stress. Time lag correlations of the velocities of buoys passing through individual points show significant correlations after lags of a few weeks, longer than the time scale of wind variations. In fact, the apparent weakness of the buoy response to the wind is perplexing since the buoys are embedded in the upper mixed layer, which is itself expected to respond to the winds.

Reports by the meteorological users of the data indicate that the buoys permitted a significant improvement in the description of the wind field, which also has considerable interest from the oceanographic point of view.

Conclusions

It took something more than 10 years to go from the inception of the idea through the development of the satellite systems to the point where the buoy array was successfully implemented. The actual buoy development specifically directed toward the FGGE array took place only in the last 4 of those years, but they were very busy ones and depended heavily on earlier results. Another year would have been welcome to allow proper testing with the Argos system, but constraints imposed by other elements of the overall FGGE would not permit this. Allowing for budgetary cycles, this means that the agencies involved made commitments to the program not less than 5 years before the experiment was actually scheduled to take place. The necessary long time scale effectively restricted participation to government agencies. At the time that commitments were required, the oceanographic significance of drifting-buoy measurements of surface currents was not well accepted, so oceanographers were reluctant to become involved in such a risky venture. This left control of the experiment to meteorologists and meteorological agencies. Fortunately these agencies took care to ensure that the oceanographic value of the data was conserved as much as possible, but there is no guarantee that this would happen in planning for future observing systems.

It is surprising and somewhat disappointing that there has not been more effort to exploit this freely available data set. One possible explanation is that it is still too soon for its value to be widely recognized, and that interest will be aroused by the publication of a few papers. Another is that oceanographers are not particularly interested in data they have not themselves collected. The planners of future large-scale programs, where the data obtained are expected to have a utility wider than the specific objective of the program, should be aware that the secondary users may not automatically and immediately recognize the value of the results being handed to them. The delay in recognition of the value of the data has led to a delay in setting up systems for archiving other drifting buoy data, so that its potential utility in climatological studies is diminished.

Most of those involved in the planning and implementation of the FGGE buoy array believed that its success would lead to the continuation of some sort of buoy array on a nearly permanent basis. This was expected to provide a climatological data base and also the opportunity to incorporate improved oceanographic sensors as they became available. In spite of the technical success achieved, only a small number of buoys are currently being deployed each year in the southern ocean. The explanation for this lies partly in the global economic decline, and partly in the length of the funding cycle. In order to set up a buoy network, national me-

teorological agencies would have to discontinue some already established type of observation.

Close study of the FGGE buoy data set serves to increase one's appreciation of some unsolved problems of oceanography. One example is our inability to estimate the wind effect on buoy drift, which also makes it evident that we don't really know what should be the Lagrangian drift of a water "particle" in the upper layer. The definition of "mean currents" and the estimation of "mean transports" become problematical in areas of high variance of velocity associated with mesoscale motions. The bottom topography is clearly important to the mesoscale eddy activity in the southern ocean, but the present level of theoretical understanding seems unable to deal adequately with this fact.

A member of our external review committee recently asked me whether I considered the time put into the planning and coordination of the FGGE system to have been well spent. My response was that it had been very satisfying indeed to have been part of something that worked better than anyone really thought possible and that the spirit of genuine cooperation which prevailed had altered my view of human nature, but that I would feel much better about my efforts when I knew that there were lots of people busy using the data in their research. I suspect this feeling is common among those involved in large data-collection exercises. I also suspect that many potential data users delicately hold back so as to allow the organizers to have the first crack at the data, thus frustrating the very organizers. Thus one of the messages I would like to convey is that it is possible to improve large experiments by contributing to the planning, but even when it is too late for that the data probably contain more information than conventional wisdom suggests, and the people who collected it would be only too happy for others to use it.

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Information Report

Climatological Atlas of the World Ocean

A project to objectively analyze historical ocean temperature, salinity, oxygen, and percent oxygen saturation data for the world ocean has recently been completed at the National Oceanic and Atmospheric Administration's (NOAA) Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey. The results of the project are being made available through distribution of the *Climatological Atlas of the World Ocean* (NOAA Professional Paper No. 13), and through objective analyses. The sources of data used in the project were the Station Data, Mechanical Bathymograph, and Expendable Bathymograph files of the National Oceanographic Data Center (NODC) in Washington, D.C., updated through 1977–1978. The raw data were subjected to quality control procedures, averaged by one-degree squares, and then used as input to an objective analysis procedure that fills in one-degree squares containing no data and smooths the results. Due to the lack of synoptic observations for the world ocean, the historical data are composited by annual, seasonal, and (for temperature) monthly periods.

Annual mean, objectively analyzed fields of temperature, salinity, oxygen, and percent oxygen saturation were produced at 33 standard oceanographic analysis levels from the sea surface through a depth of 5500 m. Seasonal mean, objectively analyzed fields of temperature and salinity were produced at 24

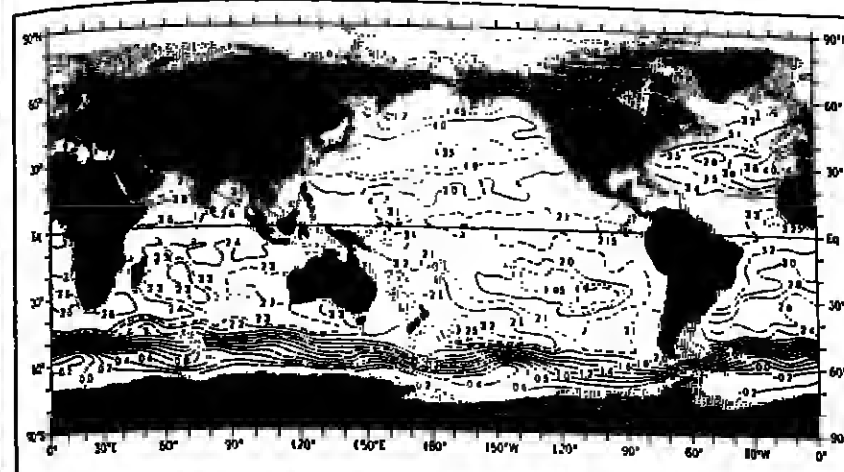


Fig. 1. Potential temperature (°C) at 2000-m depth.

standard levels from the sea surface through 1500 m depth. Monthly, objectively analyzed fields of temperature were produced at 19 standard levels from the sea surface through a depth of 1000 m.

Details of the processing of the data and their distributions in space and time appear in several ways. Contoured horizontal maps of the analyzed fields are given, as well as zonal averages of these fields over individual ocean basins. Maps of derived quantities such

Article (cont. from p. 961)

Questions Raised by Plate Tectonics

The plate tectonics model answered many questions and, as expected, revealed many new ones. At the beginning of IGY, future research on the thermal state of the earth's interior seemed to require reliable ways of estimating the temperature profile; now, with a convecting earth, the present thermal regime is not rigidly tied to cosmology; instead the boundary conditions appear to be tied to plate motions.

We have come to accept that ophiolites, an association of ultrabasic rocks, pillow lavas, and deep sea sediments defined by Steinmann early in this century, represent the remains of ancient ocean crust and mark the sutures between former fragments of continents now glued together. The absence of this tectonic in very ancient rocks has raised questions in the minds of many about the applicability of the modern plate tectonics model to the earlier history of the earth.

EOS

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Cover: Dissolved oxygen (milliliters per liter) at 1500-m depth, from NOAA's new Climatological Atlas of the World Ocean. See The Oceanography Report, this issue.

as geopotential thickness, Brunt-Väisälä frequency, and mixed-layer distributions are also presented. Basin means of the analyzed fields are presented in both tables and figures. An example of one of the standard-level analyses, the field of potential temperature at 2000-m depth, is shown in Figure 1; dissolved oxygen at 1500-m depth is shown on the cover. The relatively large meridional temperature gradient centered at approximately 55°S is associated with the flow of the Antarctic Circumpolar Current. The injection of relatively warm Mediterranean water into the north Atlantic is quite apparent. The atlas also contains discussions of the various maps and figures.

A packet containing 17 microfiches, attached to the atlas, provides three types of information: (1) computer contoured maps of all standard-level analyses for the annual mean fields, as well as the standard-level analyses of temperature and salinity for the upper 250 m of the water column for each of the four seasons; (2) maps of the distribution of temperature, salinity, and oxygen observations by one-degree squares at selected standard levels and averaging periods; and (3) statistics (number of observations, mean, and standard deviation) by five-degree squares of

temperature, salinity, oxygen, percent oxygen saturation, potential density, and anomaly of specific volume.

The data used in computing these statistics are the quality-controlled observations used to compute the one-degree square means that served as input to the objective analyses. These statistics are presented for all standard levels for the annual period and at all standard levels in the upper 250 m of the water column for each season.

Copies of the atlas (#003-017-00509-7) are available for \$11 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 (tel.: 202-789-3298).

Magnetic tapes containing the annual mean analyses (two tapes) and the seasonal analyses (four tapes) are available at \$110 per tape. A flyer giving details about the data sets and tape formats is available on request from NODC, User Services Branch, NOAA/NES-DIS/EOC21, Washington, DC 20235.

This report was contributed by Sydney Levitus, who is with the NOAA Geophysical Fluid Dynamics Laboratory, Princeton University, Princeton, NJ 08542.

Another main thrust is to better understand the continental lithosphere which contains what remains of 95% of earth's history. This should not imply neglect of the ocean, for it has been through processes acting beneath the oceans and around their margins that much, maybe most, of the lithosphere has been constructed. Nor does it imply neglect of the earth's interior since this is the source of the energy that drives the geodynamic system and of the materials that make up the crust and the rest of the lithosphere.

Potential Benefits of a New IGY

Through the international activities mentioned above, through the International Geological Correlation Program of IUGS and UNESCO, which makes it possible for geologists of many countries to get together on projects of mutual interest; through scientific ocean drilling; and through the Decade of North American Geology of the Geological Society of America, designed to produce by 1988 a series of modern maps and volumes on the geology of North America and its margins—through these projects it might appear that the solid earth people have about all of the international and interdisciplinary activities that they can stomach. Why, then, think in terms of another IGY-type program?

One reason is the large experiment. For example, we really don't know much about the continental crust. We examine the surface rocks and try to work out the structure; we examine the deeper crustal rocks where they have been brought out by diatremes, volcanic vents; we use remote sensing techniques to probe within the earth to determine its char-

Article (cont. on p. 964)



Fig. 2. Rotary drill cores: a distorted record. These cores of deep-sea sediments were obtained by conventional rotary drilling at Pacific Site 83. These cores represent the same interval illustrated in Fig. 3 and should show the same features. But the drilling technique has grossly disturbed the sediment, as evidenced by near vertical layering, flow patterns, and distorted burrows (photo courtesy of John Imbrie).



Fig. 4. Hydraulic piston cores: an undisturbed record. These cores of deep-sea sediments were obtained by hydraulic piston coring at Pacific Site 503B. Note the discrete, cylindrical worm burrows and the horizontal contacts between different layers—features which indicate that the samples contain an undisturbed record of earth history (photo courtesy of John Inbrige).

Article (cont. from p. 963)

ions about the thermal regimes in the crust: the movement of mineralized fluids and the processes through which mineral deposits are formed; the processes related to earth deformation and earthquakes; and the nature and history of the ancient crust. The costs of deep, dedicated holes are large, and considerable geological and geophysical data will be required to select suitable sites for drilling. A major thrust to better determine the nature of continental crust and the processes affecting it would have a great deal of merit as part of a large future program.

Another reason might be to focus on a specific question, such as the transfer of energy and matter to and from the solid earth on time scales that are of interest to the biologists, the oceanographers, and the atmospheric scientists. We do not have a very good grip on the magnitude and composition of the materials that are being ejected by the solid earth into the atmosphere or the oceans nor of the rates at which this happens. Similar uncertainties exist with regard to the nature of the materials being returned to the interior of the earth in the subduction zones.

On top of this, it has been suggested in recent years that extraterrestrial inputs of energy and matter may have had significant impact on the earth's environment and life and the evolution of that life. Major experiments to better define the fluxes of energy and matter into and out of the solid earth could be a fundamental part of a new international program. It goes without saying that suitable locations for such experiments would be geographically diverse, unland and at sea.

Still another reason might be to improve our ability to measure time. A century ago there was a consensus among paleontologists that the time required for observed organic evolution was of the order of hundreds of millions of years. But then, Lord Kelvin, on the basis of then-known sources of energy, calculated that the earth had been habitable for only a few tens of millions of years. This caused some panic, but it was resolved by the discovery of radioactivity. This not only provided a new source of energy, not considered by Kelvin, but it also provided methods for absolute dating of the rocks. In this case, the paleontologists won over the physicists.

Now we face a new controversy, one that suggests that short-term, singular events, such as impacts of extraterrestrial bodies, may have played a major role in the evolution of life. This suggestion is coupled to the question of whether evolution is gradual or punctuated, whether we are dealing with the survival of the fittest or, perhaps, the survival of the luckiest. We again have a problem with time, in this case with how well we can measure it. Fossil chronology was calibrated against radioactive dating and, more recently, magnetic stratigraphy has given us a way of determining comparative age in favorable locations to within, say, 10,000 years. This is very good in terms of a geological time scale of 4.5 billion years, but it is tantalizingly far from being good enough to resolve major questions about the effect of large, geological instantaneous events on organisms or on the global environment. Our tools are getting better and new methods for time discrimination are being invented. It remains to be seen whether the paleontologists or the physicists will win this one (see Figures 3 and 4).

Time discrimination is fundamental to the measurement of rates. We conclude, from the record in the rocks, that formation of new crust at the ridge axes takes place at rates of centimeters per year, but we don't know whether this takes place rapidly or intermittently because we look at the integrated result of processes operating over a long period of time. We haven't actually measured plate motions yet, but some of the new space techniques show promise of being able to do so. A focus on improving time resolution could help us to resolve some of the major questions about processes and the rates at which they occur.

I have aired a few of my own prejudices

and, knowing my colleagues in the solid earth sciences, I do not think that they would be shy about offering a few more. Most of the post-IGY programs that I mentioned earlier have had few physical resources specifically at their disposal; they depended upon the normal, discipline-oriented support systems. I believe that a well-designed program of research, focused on a limited number of principal objectives and marshaling, for a period, the proper human and physical resources, could result in significant advances and that these advances could be speeded through interaction and collaboration with our colleagues in other countries.

King Hubbert said in a recent interview that the importance of any science, socially, is its effect on what people think and on what they do. With reference to geology, he noted that in the period beginning about two centuries ago, people like Hutton, Lyell, and Darwin influenced how people thought; they gave us a geological view of the history of the earth rather than a Biblical one. Then, in the period beginning about a century ago, geologists became more utilitarian, concentrating on the search for resources. They influenced how people lived. Now, at present, perhaps it is time for geologists to again become a major force in how people think, rather than how they live.

How we think about the earth depends upon our perception of the earth. One of the striking contributions of the space probe of the 1970's was their photographs of the earth from space, which made it clear to anyone who looked at them the finite size of the earth. This appreciation was sometimes accompanied by apprehension that its finitude was coupled with a limited carrying capacity as a life support system. These apprehensions were not without foundation, but it is hard to conclude what this carrying capacity is when we have not yet been able to quantify or to fully understand the many phenomena and many interactions and feedbacks among these phenomena. We who study the earth, its waters, its atmosphere, and its place in the solar system can respond to Hubbert's challenge by striving for better understanding of these phenomena and these various interactions; by providing a solid scientific base upon which perceptions, and decisions, can be based.

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Correction: The November 13 issue of *Earth and Planetary Science Letters* contained an incorrect document number for ordering SEAN Bulletin, 8(10), September 30, 1983. The correct number is E83-010.

Volcanic Events

Miyakejima (Japan): 4 lava flows, 4 explosion craters from 10-hour eruption.

Kusatsu-Shirane (Japan): Explosions eject large tephra.

Kilauea (Hawaii): 10th and 11th major phases of E Rift Zone eruption.

St. Helens (Washington): Deformation, SO₂ emission, and seismicity increase as lava extrusion pattern changes.

Veniaminof (Alaska): Lava fountains and flow; ash emission; increased tremor.

Pavlof (Alaska): Large eruption column; tremor.

Villarica (Chile): Tephra ejection; pyroclastic flows; summit glow.

Costa Rica: Continued lava extrusion at Arenal; fumarolic activity at Poás, Irazú, and Turrialba.

El Chichón (México): Fumarole and crater lake temperatures decline.

Tangkuban Parahu (Indonesia): Seismicity continues to increase.

Una Una (Indonesia): July-August explosion times, plume heights, and photos.

Rabaul (New Britain): More than 5000 earthquakes in October, 2.5 x September total and 85 x monthly average; tilt accumulated gradually until stepwise changes of up to 40 microradians accompanied late October swarm.

Manam (Bismarck Sea): Tephra clouds; glow; rumbling; increased seismicity.

Langila (New Britain): Moderate volcanic activity; explosion events; tremor.

Pagan (Mariana Is.): Explosive eruption on September 28.

Atmospheric Effects: Lower stratospheric layer; source uncertain.

Veniaminof Volcano, Alaska Peninsula, USA (56.17°N, 159.38°W). All times are local (= UT-9 hours). After resuming in early October, eruptive activity continued through early

TABLE 1. Average and Maximum Number of B-Type Events per Day at Tangkuban Parahu, Between May and Mid-October 1983

	May-July	August		September		October First Half
		1st Week	Last Week	1st Half	2nd Half	
Average	3	10	14	70	57	72
Maximum	7	19	25	120	103	127

TABLE 2. Data on July-August 1983 Explosions of Una Una Volcano, From Volcanological Survey of Indonesia

Date	Time	Plume Height, km
July 23	1623	10
July 25	2325-0021	7.5
July 27	0400-0605	7.3
	1500-2010	7
July 28	0002-0045	8
	1630-1730	8
July 30	1615-7	6
August 1-2	1834-2000	7
August 2	2130-0230	6
	0514-0600	8
	0800-0900	8
August 2-3	1905-1100	5
August 4	0915-1100	6
August 6	1520-7	6
August 7	1100-1900	10
August 11	1115-1135	8
August 12	0047-0147	9
August 18	1013-1240	12
August 22	1203-2	8
August 24	2148-2220	8
August 25	1847-2000	5.5
August 26	1023-1159	10

November. On the night of October 23-24, residents of Perryville (population 100, about 35 km S of the volcano) observed lava fountains at the summit, and on October 30 they observed lava flowing down the SW flank of the intra-caldera cone. On October 31 and November 1, an ash cloud rose 1 km above the vent.

Bad weather prevented overflights by USGS personnel during late October. During an overflight on November 4, a very light-colored vapor plume containing a little ash rose approximately 100 m above the vent and then was blown to the S. Lava flowed down the SW side of the intra-caldera cone extending the lava flow to the S. They did not observe any melt water in the large lava pits previously melted into the caldera by the lava flow, but the view was obscured by the eruption cloud.

Seismic records available through October 8 showed low-amplitude continuous volcanic tremor beginning October 1 at 1200. On October 2 the amplitude increased to slightly less than half that during the June eruption (see *Eos*, July 5, 1983, p. 441). The tremor remained continuous and of about this amplitude through October 8. Some slightly larger bursts of tremor were recorded October 4-8. The eruptive activity reported on October 3 by the residents of Perryville was not distinguishable on the seismic record.

Information Contacts: Betty Yount, USGS, 4200 University Dr., Anchorage, AK 99508 USA; Stephen McNitt, Lamont-Doherty Geological Observatory, Palisades, NY 10961 USA.

Villarica Volcano, S. Chile (39.42°S, 71.95°W). The following is a report from Hugo Moreno Roa.

Books

The Origins of Magnetospheric Physics

James A. Van Allen, Smithsonian Institution Press, Washington, D.C., 1983, 143 pp., \$19.95.

Reviewed by Wilnot N. Hess

Professor James Van Allen has written a delightful little book on the history of research on the earth's radiation belt. This history is surely unique. It started in the 1950's with a completely new and unexpected discovery about the nature of energetic particles in near-earth space. Three decades later it is a mature science with a general understanding of the distribution and energy of particles near the earth and a reasonably good theory explaining the origins, life histories, and losses.

One man dominated the entire discovery period—James Van Allen. He and several students and young staff members at the State University of Iowa planned the experiments, built the equipment, and analyzed the data from the first four earth satellites that brought back useful data about particles in near-earth space.

In 1958, the radiation-belt era opened explosively with the launches of Explorer 1, Explorer III, Explorer IV, and Sputnik II, all carrying particle detectors, within an 8-month period. But there were carefully laid plans that led up to this explosion. Starting with the V2 Upper Atmosphere Panel in 1946, a group of U.S. scientists had been planning experiments to study particles in space, using V-2 rockets brought over from Germany and later the U.S. two-stage rocket, Aerobee. By 1955, the International Geophysical Year was being planned and a technical panel on the earth satellite program was set up with Van Allen as a member. This group reviewed proposals and assigned flight priorities for the first set of experiments to be carried out on satellites during the IGY. One of the first four experiments assigned flight priority was "a proposal for cosmic ray observations in earth satellites" by Van Allen.

Though the launching of Sputnik I by the Soviets in October 1957 caused a sensation among the public, U.S. scientists had known that the Soviets were planning to launch a rocket launching expedition when the IGY began, eruptive activity continued through early

The young radio man on the ship told Van, "I think I have it," and signals from the satellite were detected. In his notes Van does some quick calculations to arrive at an estimate of the weight of the Soviet satellite of 100 tons or more. His notes also show how upset he was at the U.S. bureaucracy for not pushing forward with the U.S. program faster. The U.S. had decided that the new Van Allen rocket should be developed even though a team under Werner von Braun, brought over from Peenemünde, Germany, had a Redstone rocket in an advanced state of development and nearly ready to go.

In the scramble after Sputnik 1, von Braun promised President Eisenhower that the first Jupiter G with scientific payload would be ready within 90 days. Van's team, with George Ludwig responsible for developing the equipment, prepared a payload that included a Geiger counter; it was launched on Explorer 1 in January 1958. In March 1958, Explorer 111 carried a Geiger counter and a tape recorder for a complete orbit.

At about this same time, Van got drawn into the AEC Argus project. Nick Christofilis, a Greek scientist working at the Livermore Laboratory, had proposed that an artificial radiation belt could be constructed in space by the explosion of high altitude nuclear bombs. The Explorer 1V satellite, with four instruments from Van's lab, was launched in July 1958. These instruments studied the particle injection from the three Argus explosions and showed that Christofilis' idea, that one could make an artificial radiation belt, was indeed correct.

Within a fourteen-month period we provided the principal scientific instrumentation for Explorers 1, 11, 111, 11V, and V and for Pioneers 1, 11, 111, and 11V. Of these nine missions, seven yielded valuable radiation data. Van Allen recounts. It took the data from Explorer 111 to convince the Iowa team that their instrument was performing properly. They could then see the transitions in radiation counts: first the expected cosmic ray counting rate, then a very high count rate, and then suddenly no counts at all. The process was later reversed, the high counts reappearing suddenly and then decreasing to expected cosmic ray levels. They soon figured out that when the counts came too fast, the system could not accept them and registered zero. The conclusion that indeed there was a very fast count rate due to some unknown particles in space led to the famous "My God, space is radioactive!"

"Forest Guards in the Villarica National Park reported that the volcano entered into a remarkable eruptive stage on October 14, after a long period of moderate activity. Continuous explosions with tephra emissions and some black pyroclastic flows over the ice-covered slopes have been observed. By night, a red glow over the summit indicates that a lava fountain is filling the crater.

"Villarica last erupted during September 1980 with small explosions and tephra emissions. Since the big lava and pyroclastic eruptions of October-December 1971, active fumaroles have been present in the main crater."

Information Contact: Hugo Moreno Roa, Departamento de Geología y Geofísica, División de Geología, Universidad de Chile, Casilla 13518, Correo 21, Santiago, Chile.

Arenal Volcano, Costa Rica (10.47°N, 84.73°W). Lava extrusion has been nearly continuous since 1968 from the active vent at 1450 m altitude at the W end of the elliptical summit crater area. The lava flow that was advancing rapidly down the NW flank in April stopped in July with its front at an altitude of 625 m above sea level. A new flow, the 42nd since 1968, began to emerge in July and by September had reached 1980 m altitude. Gas emission was continuous and strong rumblings were heard.

Information Contacts: Jorge Barquero and Erick Fernández, Programa de Investigaciones Vulcanológicas, Universidad Nacional, Heredia, Costa Rica.

Tangkuban Parahu Volcano, Java, Indonesia (6.77°S, 107.60°E). Seismicity began to increase in early June and continued to build through mid-October but no surface changes have been noted. Tectonic earthquakes and both A- and B-type microtremors were recorded. A-type events occurred irregularly, usually at one to three per day, but as many as five were detected on several days. B-type earthquakes increased substantially, as shown in Table 1.

Earthquakes

Date	Time (UT)	Magnitude	Latitude	Longitude	Depth of Focus	Region
October 1	1852	7.3M	26.58°S	70.74°W	31 km	N Chile
October 7	1019	5.2m	43.91°N	74.29°W	13 km	New York, NE USA
October 13	1057	6.7M	8.14°S	156.36°E	shallow	Solomon Is.
October 22	0422	7.0M	60.29°S	25.84°W	shallow	S Sandwich Is.
October 28	1406	6.0M	44.04°N	113.96°W	5 km	Idaho, NW USA
October 30	1012	7.1M	40.18°N	42.29°E	shallow	E Turkey

Ground deformation did not show regular changes. From 10 to 25 mm of irregular inflation and deflation were detected but their significance is doubtful. Fumarole temperatures remained stable at 96°C in the three fumarole fields (Baru, Ratu, and Upas). Civil authorities warned of the volcanic hazard and the National Park issued an alert to tourists. Within a 3-km danger zone, camping and auto parking were forbidden.

Tangkuban Parahu's most recent reported eruption was in 1969, when phreatic activity produced a thin ash layer on all sides of the volcano. Increased thermal activity in 1971 ejected small columns of mud.

Information Contact: Adjat Sudradjat, Director, Volcanological Survey of Indonesia, Diponegoro 57, Bandung, Indonesia.

Una Una Volcano, Sulawesi, Indonesia (0.17°S, 121.61°E). All times are local (= UT + 8 hours). After at least 10 days of seismicity, a major explosive eruption of Una Una began July 18. All residents of the island were evacuated before the devastating explosions of July 23 (see *Eos*, September 6, 1983, p. 537). A Volcanological Survey of Indonesia team monitored the eruption from near the island. Adjat Sudradjat provided Table 2 of their observations of explosion times and cloud heights, starting with the July 23 activity. Images and a table of data (beginning July 23) from the Japanese GMS geostationary weather satellite are shown in the September 30 SEAN Bulletin.

Information Contact: Adjat Sudradjat, Director, Volcanological Survey of Indonesia, Diponegoro 57, Bandung, Indonesia.

Meteoritic Events

Fireballs: Manitoba, Canada; Czechoslovakia, NW Italy, Netherlands 13; Indiana, Iowa, Ohio, Oregon 12; USA.

News

Computer Proposals

To expand the research community's access to supercomputers, the National Science Foundation (NSF) has begun a program to match researchers who require the capabilities of a supercomputer with those facilities that have such computer resources available.

Recent studies on computer needs in scientific and engineering research underscore the need for greater access to supercomputers (*Eos*, July 6, 1983, p. 562), especially those categorized as "Class VI" machines. Complex computer models for research on astronomy, the oceans, and the atmosphere often require such capabilities. In addition, similar needs are emerging in the earth sciences: A Union session at the AGU Fall Meeting in San Francisco this week will focus on the research computing needs of the geosciences. A Class VI supercomputer has a memory capacity of at least 1 megaword, a speed of upwards of 100 MFLOPS (million floating point operations per second), and both scalar and vector registers in the CPU (central processing unit). Examples of Class VI machines are the CRAY-1 and the CYBER 205. The high costs of these machines, the most powerful ones available, preclude most research facilities from owning one.

Impetus for the program comes from the recent report by the Panel on Large Scale Computing in Science and Engineering, commissioned by NSF and the Department of Defense and chaired by Peter D. Lax. The panel said that although the United States has been and is the leader in supercomputer technology, "this position of leadership is seriously undermined by the lack of broad scale exploitation, outside of a few national laboratories, of the scientific and engineering opportunities offered by supercomputing and by a slowdown in the introduction of new generations of supercomputers."

As a result of this report and of similar conclusions reached by other government groups, NSF solicited proposals from institutions with supercomputers to make available their unscheduled computer resources during

fiscal 1984. NSF plans to award funding to one or more institutions to make available supercomputer resources to NSF-supported researchers.

NSF is now accepting requests from researchers for computer time. Proposals should be organized according to "Grants for Scientific and Engineering Research" (NSF 83-57). Requests for computer time should be stated in equivalent CPU hours on a particular Class VI machine. To aid in the evaluation of requests, NSF asks that those submitting proposals describe prior experience with Class VI machines and to explain why access to such machines is essential for the successful completion of research. A letter describing these requirements has been sent to all active NSF awardees by Edward F. Hayes, chairman of the NSF Supercomputer Task Force. For additional information, contact the NSF program officer most appropriate to your research field.—BTR

Boninites and Island Arcs

The petrographic term to describe glassy volcanic rocks from the Bonin Islands in the Western Pacific has been around for nearly a century. Currently, however, "boninitic" has come to mean a process, and indeed boninites include a broad set of komatiite-like rocks, which characterize Pacific island arcs. Boninites are usually associated with ophiolites. Their interest geophysically, stems from their probable role in island arc formation. A while ago W. E. Cameron, E. G. Nisbet, and V. J. Dietrich drew analogies between boninites and Archaean basaltic komatiites and also the well-known variable experimental parameter "pyrolysis" (*Nature*, 280, 550, 1979).

More recently, Cameron in collaboration with his Australian National University colleagues M. T. McCulloch and D. A. Walther has alluded to "boninitic volcanism" as a broad phenomenon (*Earth and Planetary Science Letters*, 63, 75-89, 1983). In an analysis of major and minor chemical elements, HREE and LREE, and Nd-Sr isotopic compositions, they observe a chemical decoupling,

which suggests that a mixing process was involved with the formation of boninites.

In their recent paper, Cameron and his colleagues state that boninitic is the field term for "high MgO, intermediate-SiO₂ rock which are unusually primitive (Mg/(Mg + Fe)²⁺ 0.7, high Ni and Cr) and are unique mineralogically: sometimes containing clinopyroxene, olivine, or low-Ca pyroxene in glass, which is 50-50% by volume of the rock. In a sense comparable to the adding or subtracting of components in the laboratory to make "pyrolytic" come out right, Cameron and colleagues suggest, boninites have had a compound geologic history.

A two-component mixing model is supported by the analyses of boninites from the Bonin Islands, Cape Vagel peninsula, Papua New Guinea, New Caledonia, New Zealand, and Cyprus. The two components include an incompatible, element-depleted ilherzuite type of rock and a hydrous, incompatible, element-enriched fluid melt phase. The enriched component fluids could have been derived from many sources. Cameron and colleagues prefer the following: The presence of two components in boninitic genesis may be linked to the common juxtaposition of subducted crust and depleted mantle in subduction zones, allowing ample opportunity for these sources to interact.—PMB

Geophysical Events

This is a summary of SEAN Bulletin, 8(10), October 31, 1983, a publication of the Smithsonian Institution's Scientific Event Alert Network. The entire Veniaminof, Villarica, and Tangkuban Parahu reports are excerpts. The complete bulletin is available in the microfiche edition of *Eos* as a microfiche, order document E83-010 for one copy of \$2.50 from AGU Fulfillment, 2000 Florida Avenue, NW, Washington, DC 20009. For the paper reprint, order the SEAN Bulletin (giving volume and issue numbers and issue date) through AGU Separates as the above edition; the price is \$5.50 for one copy of each issue number, for those who do not have a credit account, \$8 for those who do; additional copies of each issue number are \$1. Subscriptions to

Books (cont. from p. 965)

celestial radio catalogue at the millisecond level for the simultaneous use of two frequencies during Very Long Baseline Interferometry (VLBI) sessions. The second paper, by K. J. Johnston and J. S. Ulvestad, is devoted to celestial frame by comparing several radio source catalogues. Some useful recommendations are made for future work, particularly by proposing a set of about 40 sources to be observed by all investigators.

Two papers were related to the definition and maintenance of a conventional terrestrial system by space techniques, especially VLBI. S. Manabe's contribution was devoted to some numerical comparisons among several possible networks. In case of a VLBI network, simulations have shown that 80% of the actual station displacements were recovered for an eight-element network. The paper is not self-explanatory. The paper is not self-explanatory. The paper is not self-explanatory.

The paper by M. K. Fujimoto et al. dealt with relativistic modeling of reference frames. Relations between solar system barycentric, geocentric, and topocentric frames were discussed but formulas for the relation between only the first two are presented. Although very dense for a non-specialist, this presentation is rather comprehensive and I recommend it.

Five papers belong to session 2 on earth rotation. The first one, by D. D. McCarthy et al., dealt with results of connected element interferometry. Present results are derived from only one baseline. They show an internal precision of 0.2-0.8 ns and an accuracy of 0.5-1.0 ms. As such results can be obtained only a few days after the observation time, they are particularly suitable for a rapid service. A second baseline and a better modeling of refraction will improve these results. Other papers covered the NGS Polar system; the results of a global analysis of 10 years of VLBI data collected by the Deep Space Network; the Jet Propulsion Laboratory (JPL) TEMPO program for a rapid and operational determination of earth rotation parameters; and a pioneering VLBI experiment.

Three papers from session 3, on radio-interferometric surveying, are included in the proceedings. The first one, by C. Lundquist, reported VLBI determination of a 600-m baseline between two radio telescopes at Onsala, Sweden. Two experiments using a Mark III system show a sub-centimeter repeatability, and an agreement with a conventional surveying method better than 4 cm. A closure experiment with various trans-Atlantic baselines, Haystack-Onsala, performed between 1972 and 1978 shows a good agreement in length (2 cm) but a slightly worse agreement in orientation (up to 1 m in the Z component). More extensive comments on this last result would have been helpful.

A second paper, by W. Beyer et al., described the European Radio Interferometry and Doppler Campaign (ERIDOC). Several

bandwidth synthetic Mark II experiments provided baselines between six European radio telescopes with a repeatability better than 30 cm. Comparison with Doppler-derived baselines, using colored receivers and DMA precise ephemerides, shows generally good agreement if one removes a scale and rotation bias. Nevertheless, the values of these parameters do not fully agree with those found by L. Hothem et al. in 1982. Further investigations about intercomparisons, especially on a full error budget, including local connections, are needed.

The last paper, by D. W. Trank et al., was devoted to results of the National Aeronautics and Space Administration/JPL mobile VLBI stations, used to survey some 17 sites in California from 1974.

Session 4 contained six papers devoted to VLBI systems. The first three covered the Mark III system; the next two described the Japanese K-3 system, fully compatible with Mark III; and the last presented the JPL/CIT correlator named Mark II, which is also compatible with the Mark III system.

Session 5 provided five contributions on atmospheric and ionospheric propagation effects; session six, four papers on new instrumentation and techniques; and session seven contained five papers devoted to future plans.

This report will provide a good review of the state of the art of radio-interferometric techniques as applied to geodesy.

C. Boucher is with the Institut Géographique National, 91460 Saint-Mandé, France.

AGU
Congressional Science
Fellowship

The individual selected will spend a year on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science and be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to \$28,000, plus travel allowance.

Interested candidates should submit a letter of intent, a curriculum vitae, and three letters of recommendation to AGU. For further details, write Member Programs Division, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009 or telephone 462-6903 or 800-424-2488 outside the Washington, D.C. area.

Deadline: March 31, 1984

University of Texas at Austin/Geology Chair. The Department of Geological Sciences seeks a person at the rank of full professor to occupy the recently endowed Gentry Chair effective September 1, 1984. Teaching obligations include one undergraduate or graduate course each semester and the supervision of graduate students in the area of research. The person's willingness to teach courses for non-geologists on occasion is desirable. The person's field of research must be one that is related in a broad sense to the exploration of hydrocarbons. The Gentry endowment will provide the chair holder with modest funds for support of travel and research activities. Applicants should submit a detailed resume, names and addresses of five references, and a statement of teaching and research interests by February 1, 1984 to Dr. E. F. McBride, Chairman, Department of Geological Sciences, P.O. Box 7900, Austin, Texas 78717-1695.

The University of Texas at Austin is an Equal Opportunity/Affirmative Action Employer.

The College of William and Mary/Physics Faculty Position. William and Mary expects to have a tenure-track opening at the assistant professor level for August, 1984. Preference will be given to applicants in the fields of theoretical plasma physics (including computer simulation, nonlinear mechanics, or statistical mechanics). The physics department currently consists of 22 faculty, 7 postdoctoral research associates, and 40 Ph.D. candidate graduate students. Plasma physics funding is currently from NASA and the Department of Energy. Please send vitae and at least three references to the Search Committee, Physics Department, College of William and Mary, Williamsburg, Virginia 23185. William and Mary is an affirmative-action, equal opportunity employer; women and minority applicants are encouraged to apply.

The University of New Mexico/Mass Spectrometry. The Department of Geology, University of New Mexico, Albuquerque is seeking a person for a research associate position in the stable isotope laboratory. The position includes responsibility for operation and maintenance of mass spectrometers and high vacuum extraction systems, sample preparation and isotopic analyses. The position also provides opportunities for collaborative research in isotopic geochemistry leading to publication. A Ph.D. in geochemistry, inorganic chemistry, or physical chemistry with research experience involving mass spectrometry and high vacuum technology is required. Send a letter of application, resume, and the names and addresses of three individuals willing to serve as referees to: Dr. J. W. Valley, Department of Geology, University of New Mexico, Albuquerque, NM 87131. Closing date for applications is February 1, 1984. The availability of this position is contingent on final budget approval.

The University of New Mexico is an equal opportunity employer.

University of Massachusetts, Amherst/Faculty Position in Stratigraphy/Micropaleontology. The Department of Geology and Geography invites applications for a tenure-track position at the assistant professor level in stratigraphy/micropaleontology. Research and supervision of graduate students in these fields will be expected. Additional research interests in paleoceanography or paleogeography are desirable. The successful candidate will be expected to teach a one-semester course in stratigraphy every year, a one-semester course in micropaleontology every other year, and to teach additional courses in his/her area of expertise. Application including a resume, statement of research interests, and the names and addresses of at least three referees should be sent to: Dr. J. W. Valley, Department of Geology and Geography, University of Massachusetts, Amherst, MA 01003.

The University of Massachusetts is an Affirmative Action/Equal Opportunity Employer.

Hydrologic Modeler/University of Wisconsin-Milwaukee. The Department of Geological and Geophysical Sciences at the University of Wisconsin-Milwaukee invites applications for a probable tenure-track position at Assistant Professor beginning in Fall, 1983, to join a broad program in hydrologic, geologic, atmospheric and geophysical sciences. Applicants' primary strength should be in the application of numerical models to ground water flow and chemical transport systems. A strong chemical background or coexisting experience with flow in fractured media or contaminant migration would be helpful. Further, ability to apply modeling techniques to problems in other aspects of the geosciences will be important.

The successful candidate will be expected to teach an applied senior level course in the theory and application of finite element, finite difference methods in hydrology and geophysics. The candidate is expected to develop additional graduate level courses in hydrology and to teach general geology at the undergraduate level. Ability to teach physical fluid dynamics would be valuable.

Research programs at UWM include lake infiltration into aquifers, use of aquifers for compressed air storage, Great Lakes contamination and sediment processes, the use of applied geophysics in detection of hydraulic properties and flow, and geologic modeling. Facilities include a Great Lakes Research Center with research vessels and per facilities, an Urban Research Center and a rural field station. Candidates should forward resumes, complete transcripts and three letters of recommendation to Professor D. S. Cherkauer, Chair, Department of Geological and Geophysical Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI 53201. Salary range has not yet been formally approved, but will probably be in the \$28,000-\$32,000 range. Closing date for applications is January 31, 1984. UWM is an affirmative-action, equal opportunity employer.

J. J. Papke, Director, ISMD
South Dakota School of Mines and Technology
600 East University Avenue
Rapid City, South Dakota 57701-3998
For additional information, call (605) 394-8182. SDSMT is an affirmative-action/equal opportunity employer.

Texas A&M University/Geological Oceanography Position. The Ocean Drilling Project (ODP) is seeking applications for the following anticipated positions: Several full-time staff scientists (Ph.D. required). These openings, in various fields of marine geoscience, are anticipated to be filled over a one-year period beginning in October 1983. The successful candidates will be expected to participate in approximately two months per year aboard a scientific drilling ship. These individuals will be responsible for all research activities prior and subsequent to the drilling, including the publication of results. The successful candidates will be expected to attend the JOIDES panel meetings relating to their disciplines, held in Houston, Texas, in 1984. Previous experience and/or graduate degree in geology or related science highly desirable. These positions require participation of about 6-8 months per year (flexible) aboard a scientific drilling ship. Applicants should submit a letter of application, curriculum vitae, and names of 3 references to: Dr. Philip D. Robinson, Project Director, ODP, Department of Geology, Texas A&M University, College Station, TX 77843.

Texas A&M University is an Equal Opportunity Employer.

SKW ENTERPRISES
Box 3135
Boulder, Colorado 80307

Postdoctoral Research Position/University of California, Berkeley. A postdoctoral research position in petrophysics is available immediately in the Department of Mechanical Engineering. The Department has recently installed in the Petroleum Engineering Laboratory a nuclear magnetic resonance facility, having a large magnet gap. The successful candidate must have a knowledgeable and experienced in NMR techniques, and will be expected to employ this and other petrophysical research techniques in an interdisciplinary approach to a program directed at the petrophysics of porous sedimentary rocks, and the physical properties of petroleum. Sources of other University Department and of the Lawrence Berkeley Laboratory will also be available to the research program.

Send resume and the names of three references to Professor W.H. Somerton, Department of Mechanical Engineering, University of California, Berkeley, CA 94720. The University is an Equal Opportunity/Affirmative Action Employer.

Geophysicist, Tectonophysics/Georgia Tech. The School of Geophysical Sciences at Georgia Tech invites applications for a faculty appointment in Earth Sciences. Applicants must have an outstanding research potential demonstrated by several years of postdoctoral experience or a well-established research record. No field of specialization is excluded; preference will be given to recruiting candidates with a background in geophysics/tectonophysics.

The School of Geophysical Sciences has an expanding and active research program in many areas of Earth and Atmospheric Sciences. The School has 23 full-time faculty members and over 50 graduate students.

Applications including resume, phone numbers, and the names and addresses of at least three referees should be submitted to Jean-Claude Martinez, Chairman, Geophysical Sciences Search Committee, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30332.

The Georgia Institute of Technology is a unit of the university system of the State of Georgia. Georgia Tech is an affirmative action/equal opportunity employer.

University of Washington/Paleontology/Geochronology. The Department of Geological Sciences invites applications in the areas of paleontology/paleobiology and geochronology (especially economic or isotope geochronology). We are interested in candidates who will establish exceptional innovative research programs. Postdoctoral research experience is highly desirable. One opening is available beginning September 1984. This is a tenure-track position at the rank of Assistant Professor or higher under exceptional circumstances. A second position may be available in September 1985. A paleontology/paleobiologist may seek a joint appointment with the Burke Museum on campus. A successful candidate in either area will be expected to teach at both the undergraduate and graduate levels.

Applicants should send vitae and names of four references to John R. Adams, Chairman, Department of Geological Sciences, AJ-20, University of Washington, Seattle, Washington 98195. Closing date for applications is February 15, 1984. The University of Washington is an Affirmative Action/Equal Opportunity Employer.

Climatologist-Postdoctoral Research Scientist/Lamont-Doherty Geological Observatory of Columbia University. Individual should be interested in climatic variability over the past several centuries. Tree-ring data and climatic reconstructions are available for study. Postdoctoral research position in applied geomorphology and hydrogeology. The long-term data to be used in studying various forcing phenomena and regional variations. Experience in data analysis and knowledge of programming in FORTRAN and BASIC will be extremely useful. Applicant should have a strong commitment to research and anticipate being involved in preparation of papers and proposals.

Send resume, curriculum vitae, and names of at least three referees by 10 January 1983 to: Gordon C. Jacoby
Lamont-Doherty Geological Observatory
Palisades, New York 10964
Position is a one-year appointment with possible second-year renewal.
Columbia University is an affirmative action, equal opportunity employer.

Mineralogist/Petrologist/Geochronologist-South Dakota School of Mines. A position as Research Scientist I (research equivalent of assistant professor) is available in the Institute for the Study of Minerals and Deposits (ISMD) at the South Dakota School of Mines and Technology, Rapid City, South Dakota. A Ph.D. degree in the general areas of mineralogy-petrology-geochemistry is required and the Ph.D. degree must be in hand. The successful candidate will be expected to teach courses at the senior and graduate student level and to establish innovative, forward-looking research programs. Applicants with a Ph.D. in mineralogy or petrology and a vigorous research background in any subfield of solid-earth geophysics will be considered. However, applicants with prime interest in studying global tectonics or in studying physical properties of the earth's crust and core will receive preference. Curriculum vitae and four letters of reference should be sent prior to 31 January 1984 to:

Professor Ronald T. Merrill
Chairman, Recruitment Committee
Geophysical Program AR-40
University of Washington
Seattle, WA 98195

The University of Washington is an affirmative action/equal opportunity employer.

University of Georgia/12-month tenure-track faculty appointment in the School of Forest Resources. Qualifications: Ph.D. in hydrology or forest hydrology with at least one degree in forest resources. Background should include forest water management and quantitative sciences. Responsibilities: Teach undergraduate and graduate level courses in forest hydrology and watershed management. Develop research program in forest hydrology and forest water management. Salary: Commensurate with training and experience. Position available July 1984. Applications will be accepted until February 1984. Submit resume, transcripts, and names of at least three references to:

Klaus Stelbrink, Chairman
Hydrology Search Committee
School of Forest Resources
University of Georgia
Athens, GA 30602
Telephone 404-542-1578
The University of Georgia is an Equal Opportunity/Affirmative Action Institution.

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CSIRO conducts scientific and technological research in laboratories located throughout Australia and employs about 7,500 staff, of whom some 2,500 are professional scientists. The Organisation's research activities are grouped into five Institutes: Animal and Food Sciences, Biological Resources, Energy and Earth Resources, Industrial Technology and Physical Sciences. The CSIRO Division of Environmental Mechanics is a member of the Institute of Physical Sciences.

Research in the Division of Environmental Mechanics is directed primarily at gaining a better understanding of the biological and physical processes of the soil-plant-atmosphere system with particular regard to the transport of energy, water, nutrients and other materials. Facilities include laboratories for soil physics, solar radiation, fluid mechanics, micrometeorology and plant physiology, as well as mobile laboratories for study of the field environment. The laboratory has a large and well instrumented boundary layer wind tunnel, and computer facilities for the collection and analysis of experimental data. The Division has a micrometeorology field site located 45km from Canberra.

Divisional staff at present include 15 research scientists (biologists, physicists and mathematicians) together with experimental and technical staff, and is usually augmented by several visiting research workers.

The Division's Micrometeorology program investigates the turbulent transfer of heat, momentum, and water vapour in the atmospheric surface layer, and within and above plant canopies, research which involves parallel and complementary work in the field and in the Division's wind tunnel. Special emphasis is given to the effects, on these transfer processes, of complicated surface geometry including barriers, hilly terrain and spatial variability of surface roughness.

Applications are invited for the following position:
A2857 — Micrometeorologist/Fluid Mechanicist.

DUTIES: To undertake field, wind tunnel and theoretical studies on aspects of turbulent flow and transport relevant to industry, agriculture and the community, and to assist in the application of the results of this work to practical problems.

Applicants should have a PhD degree or equivalent, supported by evidence of research experience in the field of fluid mechanics and/or heat and mass transfer. Experience in the modelling of turbulent flows by wind tunnel or other laboratory techniques is highly desirable.

A fixed term appointment of three years within the classification of Research Scientist. An applicant with an outstanding research record may be offered an appointment of a higher level. Australian Government superannuation benefits are available.

Applications, stating full personal and professional details, the names of at least two scientific referees, and quoting reference No A2857 should be directed to:

The Chief
CSIRO Division of Environmental Mechanics
CSIRO
GPO Box 821
CANBERRA ACT 2801
AUSTRALIA
By 5 January 1984.

University of Wisconsin-Madison/Tenure Track Position. The Department of Geology and Geophysics invites applications for an anticipated tenure-track position at the assistant-professor level in applied geomorphology and hydrogeology commencing in August 1984. The applicant should be committed to developing a strong research program as well as teaching undergraduate courses in some aspect of geomorphology and hydrogeology. The Ph.D. is required. Applicants with course work in engineering and an interest in the field application of geologic principles are especially encouraged to apply.

Send letter of application outlining your professional goals, transcripts, resume, copies of publications, and three letters of reference to Dr. David M. Mickelson, Department of Geology and Geophysics, Weeks Hall, University of Wisconsin, Madison, WI 53706.

The University of Wisconsin is an equal-opportunity/affirmative action employer.

Post-Doctoral Position/Naval Postgraduate School. The Ocean Turbulence Laboratory has available a post-doctoral position for a person interested in analysis and interpretation of oceanic turbulence data. The tenure is for 1 or 2 years. The successful candidate will be expected to develop a research program in the field of oceanic turbulence. The Ph.D. is required. The successful candidate will be expected to teach courses at the senior and graduate student level and to establish innovative, forward-looking research programs. Applicants with a Ph.D. in oceanography or a related field and a vigorous research background in any subfield of solid-earth geophysics will be considered. However, applicants with prime interest in studying global tectonics or in studying physical properties of the earth's crust and core will receive preference. Curriculum vitae and four letters of reference should be sent prior to 31 January 1984 to:

Professor Ronald T. Merrill
Chairman, Recruitment Committee
Geophysical Program AR-40
University of Washington
Seattle, WA 98195

The University of Washington is an affirmative action/equal opportunity employer.

Physical Oceanographer/The Woods Hole Oceanographic Institution. Plans to make a tenure-track appointment as Assistant Scientist in the Department of Physical Oceanography. Applicants should have a degree in Physical Oceanography or a closely related field and, preferably, some post doctoral experience. A candidate's area of expertise in oceanography is not specified, but a working knowledge of fluid dynamics is an important qualification. Please send one to the Chairman, Physical Oceanography Department, Box 2, WOODS HOLE OCEANOGRAPHIC INSTITUTION, Woods Hole, MA 02543. An equal opportunity employer.

Physical Oceanographer/Oregon State University. Assistant or Associate Professor, depending on experience. Applicants may be observationalists or theoreticians but must have a Ph.D. in the physical sciences, have demonstrated the ability to conduct independent, high-quality research and are expected to obtain research funding. Duties include teaching and supervision of graduate students. Interested candidates should submit a resume and names of three referees by February 1984 to: Dr. G. Ross Heath, Dean, College of Oceanography, Oregon State University, Corvallis, OR 97331.

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For further information, call toll free 800-424-2488 or, in the Washington, D.C. area, 462-6903.

POSITIONS AVAILABLE

Colorado School of Mines/Research Fellowship. Research Fellowship in the isotope geochemistry of extraterrestrial rocks. The study concentrates on geochemistry and geochronology of Lu-Hf, Sm-Nd, Rb-Sr, U-Th-Pb systems in meteorites, lunar samples, and relevant terrestrial systems. This is a joint research program with the Colorado School of Mines and the U.S. Geological Survey. The appointee will perform most of the experiments at the USGS Isotope Branch, where up to date facilities are available for isotopic studies. Candidates should have a Ph.D. in geochemistry or a related science. Experience in mass spectrometry or radio chemistry is desirable. The stipend is \$21,000-\$25,000 per year depending on experience and tax status. Begins on February 2, 1984 for 1 or 2 years. Send resume, two letters of recommendation, and a statement of research interests to: Thomas R. Waldman, Dept. of Chemistry/Geochronology, Colorado School of Mines, Golden, Colorado 80401. Phone: (303) 273-3000. CSMI is an equal opportunity/affirmative action employer.

Institute of Biogeography/University of Hawaii. The Department of Geology and Geophysics at the University of Hawaii, is searching for a creative marine scientist for a tenure track position at the Assistant or Associate Professor level. The successful candidate will be expected to contribute to introductory courses offered by the department, teach advanced undergraduate courses, and maintain a research program. Hamilton College is an equal opportunity employer. Women and minorities are encouraged to apply.

Ohio State University/Mineralogist. The Department of Geology and Mineralogy invites applications for a tenure track position in mineralogy or mineralogy/petrology that has been vacated. The successful applicant will be expected to interact with other members of the faculty in the fields of mineralogy, petrology, geochemistry, and geophysics.

A Ph.D. or equivalent is required. The successful applicant will be expected to teach graduate and undergraduate courses, conduct research, and supervise graduate students. Rank and salary will be commensurate with experience and research record. Please send applications to:

Dr. David H. Elliot
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210

Applications should include resume, statement of research record and interests, and the names of at least three persons who can provide recommendations. The closing date for applications is December 1, 1983; the appointment will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling (614) 429-6331.

The Ohio State University is an equal opportunity/affirmative action employer.

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Physicist/Underwater Acoustician. Results to other Naval elements having a need for those results, and insuring that the program content meets anticipated Navy needs. Incident will be required to describe and justify his/her programs both in writing and orally within the organization and to responsible bodies in the Navy and DoD.

Applicants must have a Ph.D. degree or equivalent in physics or a related physical science and a minimum of three years of progressively responsible professional experience. At least one year of experience must be comparable in difficulty and responsibility to the next lower level in the Federal Service. Demonstrated research experience is preferred. Equivalent combinations of professional experience and graduate education may be acceptable.

Interested persons should submit a resume or Standard Form 171, Personal Qualifications Statement (available at Federal Job Information Centers or from the address below), to:

OFFICE OF NAVAL RESEARCH
ATTN: Announcement #83-56 (EOS) • 800 North Quincy Street • Arlington, VA 22217
Applications will be accepted through 31 January 1984 and must be received by that date. For further information and supplemental forms, please call (202) 696-4705.

Hydrogeologist/University of Illinois at Urbana-Champaign. The Department of Geology has a tenure-track position for a hydrogeologist to fill a permanent, tenure-track faculty position. The appointee will be at the Assistant Professor level. Salary is negotiable. A Ph.D. is required. The successful candidate will be expected to teach courses in hydrogeology, to participate in our undergraduate hydrogeology program, and to maintain and develop our existing research program in hydrogeology. For equal consideration, application including the names of three referees should be sent by February 1, 1984 to:

Professor R. James Kirkpatrick
Department of Geology
245 Natural History Building
1801 West Green Street
Urbana, IL 61801
Ph: (217) 335-3642

The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

Hydrogeologist/University of Illinois at Urbana-Champaign. The Department of Geology has a tenure-track position for a hydrogeologist to fill a permanent, tenure-track faculty position. The appointee will be at the Assistant Professor level. Salary is negotiable. A Ph.D. is required. The successful candidate will be expected to teach courses in hydrogeology, to participate in our undergraduate hydrogeology program, and to maintain and develop our existing research program in hydrogeology. For equal consideration, application including the names of three referees should be sent by February 1, 1984 to:

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The Johns Hopkins University/Quantitative Morphological Geologist. The Department of Earth and Planetary Sciences invites applications for a tenure-track faculty position in some quantitative aspect of metamorphic geology, effective July 1, 1984. The appointee will be expected to develop an innovative research program, and responsibilities will include undergraduate and graduate teaching, and supervision of doctoral candidates. Strong research background and research interest in the chemical, isotopic, or physical aspects of metamorphism are required, as is the Ph.D. degree. Field experience is also desirable. Applications from women and minority candidates are encouraged.

To apply, send curriculum vitae, publications list, and the names of at least three referees to: Dr. David R. Velten, Dept. of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218. Application deadline is January 15, 1984.

The Johns Hopkins University is an equal opportunity, affirmative action employer.

Naval Postgraduate School, Faculty Positions/Meteorology. The Department of Meteorology, Naval Postgraduate School, invites applications for a tenure-track and a non-tenure track position at the Assistant or Associate Professor level. The positions are for persons whose teaching and research interests are in the fields of remote sensing and synoptic meteorology. The successful applicant will teach graduate and undergraduate courses and will be expected to develop an active research program that complements higher teaching. Rank and salary will be commensurate with the experience and qualifications of the successful applicants. Send a resume,

names and addresses of three references, and a statement of academic and research interests, including availability for a non-tenure position, by 31 Dec. 1983 to: Professor R. J. Renard, Chairman, Department of Meteorology, Naval Postgraduate School, Monterey, California 93943. [Area code 408-646-2516].

The Naval Postgraduate School is an equal opportunity employer. The Carnegie Institution of Washington/Postdoctoral Fellow 1984-1985, Department of Terrestrial Magnetism. Endowed postdoctoral fellowships in private institutions, emphasizing maximum freedom of research in areas of geology, geophysics, isotope and trace element geochemistry, cosmochronology, geochronology, paleontology, and earth and planetary formation. Renewable for second year. Completed applications due February 1, 1984. For information write Fellowship Committee (1), Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, 524 Broad Branch Road, N.W., Washington, D.C. 20015. Women and minority candidates encouraged. Carnegie Institution of Washington is an EOE/AAE.

Microprobe Technician/South Dakota School of Mines and Technology. Applications are invited for a position as microprobe technician for the Institute for the Study of Mineral Deposits. The microprobe is an ETG (MAC-3) with 3 spectrometers with Krid automation and a quantitative PGT energy dispersive system. The successful applicant will be responsible for the day-to-day operation of the instrument including maintenance and repair of hardware, development of software, routine analysis

of minerals, and assistance to students. A background in electronics is required. Salary commensurate with experience and qualifications. Applicants should send a resume and three letters of recommendation to: J. J. Papke, Director, Institute for the Study of Mineral Deposits, South Dakota School of Mines and Technology, Rapid City, South Dakota 57701-5085. Closing date: March 31, 1984. For additional information, call (605) 394-6132.

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GRADUATE STUDENT NASA TRAINEESHIPS The Florida State University is accepting applications from prospective graduate students for participation in its NASA sponsored Traineeship Program in Oceanographic Remote Sensing Technology and Physics of Air-Sea Interaction. The stipend for a year is \$10,000. Students may be enrolled for a degree in either oceanography or meteorology. For further information or application, please write:

Dr. James J. O'Brien, NASA Traineeship Program, Department of Oceanography, The Florida State University, Tallahassee, Florida 32306 (904) 644-4381

applied/St. Paul area. Applicants must have a background in geology, hydrology or engineering with specific coursework and/or experience in groundwater hydrology. A Master's degree may be substituted for a portion of the experience requirement in writing and evaluating ground water models. The position will include limited field work and contract supervision. For application, information please contact:

Richard Nelson, Minnesota Pollution Control Agency, 1935 West County Road, Roseville, Minnesota 55113 Telephone: (612) 296-7761

The State of Minnesota is an equal opportunity employer.

STUDENT OPPORTUNITIES

GRADUATE STUDENT NASA TRAINEESHIPS The Florida State University is accepting applications from prospective graduate students for participation in its NASA sponsored Traineeship Program in Oceanographic Remote Sensing Technology and Physics of Air-Sea Interaction. The stipend for a year is \$10,000. Students may be enrolled for a degree in either oceanography or meteorology. For further information or application, please write:

Dr. James J. O'Brien, NASA Traineeship Program, Department of Oceanography, The Florida State University, Tallahassee, Florida 32306 (904) 644-4381

Important offices of the IAG: Ivan I. Mueller (Department of Geodesic Science and Surveying, Ohio State University) as first vice president; John D. Bossler (NOAA/NOS) as president of the section of positioning; and Richard A. Anderson (Naval Surface Weapons Laboratory) as president of the section on advanced space technology (see list below for these and other new IAG officers). The first vice president is a member of the IAG Bureau, while the section presidents are members of the Executive Committee. The fact that three Americans were elected to the Executive Committee is most unusual and reflects the dominant role that Americans play in international geodesy at this time.

The IAG delegates approved 17 IAG and 6 IUGG resolutions, including statements of the currently most accurate geodetic constants, recommendations for location of collocated observations stations for different survey methods, a plea for the release of restricted gravity data, etc. (see list of IAG resolutions below).

John Wahr (age 26) of the University of Colorado won the esteemed Bonford Award, a prize for scientists under 40.

Ivan I. Mueller
Ohio State University

Resolutions

Reproduced below are resolutions adopted by IAG during the 18th General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Hamburg, August 15-27, 1983.

The resolutions passed at each quadrennial general assembly of IUGG and of its member associations are an important barometer of current opinion in the geophysics community and can be a powerful tool in the development of the scientific programs to which they are addressed. The resolutions will help advance programs, however, only if they are used. Carried back home by the national committees which make up the IUGG, the resolutions can spread information worldwide on programs that promise to most effectively advance geophysical knowledge. IUGG and its member associations intend that member groups will present the resolutions before their respective bodies and otherwise use them to make decisions and actions of international scientific thought.

The 18 resolutions adopted by IUGG as a whole appeared in *Eos*, October 4, 1983, p. 582.

The International Association of Geodesy

1. Recognizing its responsibility for providing representative estimates for fundamental geodesy to the scientific community, and having decided to update current numerical values at each General Assembly, recommends that the following numerical values be considered currently representative estimates:

• velocity of light in vacuum:
 $c = (299,792,458 \pm 1.2) \text{ m s}^{-1}$

• Newtonian gravitational constant:
 $G = (6.673 \pm 1) \times 10^{-11} \text{ m}^3 \text{ s}^{-2} \text{ kg}^{-1}$

• angular velocity of the earth (rounded value):
 $\omega = 7.292,115 \times 10^{-11} \text{ rad s}^{-1}$

• geocentric gravitational constant including the atmosphere:
 $GM = (5.986,044 \pm 1) \times 10^7 \text{ m}^3 \text{ s}^{-2}$

• geocentric gravitational constant of the atmosphere only:
 $GM_A = (55 \pm 0.5) \times 10^7 \text{ m}^3 \text{ s}^{-2}$

• second degree harmonic coefficient (free from permanent tidal deformation):
 $J_2 = 1.082,629 \pm 1 \times 10^{-6}$

• equatorial radius of the earth:
 $a = (6,378,136 \pm 1) \text{ m}$

• equatorial gravity:
 $\gamma_e = (9.78,032 \pm 1) \times 10^{-1} \text{ m s}^{-2}$

• flattening (f):
 $f = (298,257 \pm 1) \times 10^{-6}$

• geoidal potential:
 $W_0 = (6,265,686 \pm 2) \times 10^6 \text{ m}^2 \text{ s}^{-2}$

• (maxillary) parameters (rounded values)—
equatorial flattening (f_1):
 $f_1 = 80,000$

longitude of major axis of equatorial ellipse:
 $\lambda_1 = 15^\circ \text{W}$

The value of c and its standard error are taken from the CODATA System of Physical Constants of 1973. The standard errors are intended to represent realistic estimates of accuracy, and the value of c is accurate to the given digits.

It is remarked that more details on basic geodetic parameters are found in the Report of SSC 5.39 presented at this General Assembly.

It is particularly emphasized that these values are current estimates, whereas for reference purposes the Geodetic Reference System 1980, as adopted by the IUGG at the 17th General Assembly should be used.

2. Recognizing the importance in mountain areas of precise geoid determination by a combination of aerogeoid, gravimetric and other data, and noting the progress achieved in this respect in various regions and the development of new observational and computational techniques, recommends the active continuation of this work and its support by national authorities.

3. Noting the existence of global and regional satellite programs using space techniques for positioning, such as MEKAT/COGITS and the crucial dynamic project initiated by NASA, and recognizing the significance of such programs for long-term study, and dynamic investigations of the earth and its environment, and considering that: (1) the success of such programs critically depends on the establishment and maintenance of networks of terrestrial observing stations, and (2) such stations may be intermittently occupied by a variety of instruments and over a total time span of possibly several decades or longer, strongly urges the countries involved in such establishment and maintenance to devote utmost care to station selection, monumentation and survey strategy, so as to enable unambiguous reoccupation to an accuracy compatible with the scientific objectives of the programs.

4. Noting that: (1) a better knowledge of the gravity field is essential for the application of the next generation of altimetric satellites to the study

of ocean dynamics, and (2) many areas of the world have no gravity survey, including areas of great importance in the understanding of the earth's structure and evolution, and (3) many other areas do not have adequate gravity coverage; considering that such improved gravity field information can most practically be obtained from advanced satellite missions using satellite-to-satellite tracking or gravity gradiometry; recommends that all countries involved with space programs give high priority to such satellite missions.

5. Recognizing the important role that global satellite laser and radio tracking systems will have in the computation of precise orbits for future geodesic and oceanographic satellites, and noting that topics of central concern to orbit analysis are the determination of (1) the appropriate terrestrial reference frames for describing the tracking stations locations, (2) the precise locations of the individual tracking stations in these reference frames, and (3) any scale and/or relative origin bias in the independent reference frames of the laser and radio tracking data, and considering the need for data from such systems grouped or common data to reduce any scale and/or origin bias, recommends that particular efforts be made to group radio and laser tracking systems at common sites during future international tracking campaigns with emphasis on achieving global coverage for the collocated systems.

6. Recognizing the general need for establishing orbit for altimetric satellites in support of investigations in geodesy and oceanography, and noting (1) the particular contributions that such altimetric satellites as ERS-1, Poseidon and TOPEX may make to efforts to understand the general ocean circulation, and (2) that all these satellites are planned to be in orbit during the same period (1985-1991), recommends that cooperative global tracking campaigns be organized to provide the data sets for precise orbit computations for the satellites.

7. Recognizing the increasing importance of precise, space-related positioning systems such as those of laser ranging and very long baseline interferometry (VLBI) for investigations of the kinematics and dynamics of the earth and its environment, recommends that national authorities extend their support for the development and operation of these systems.

8. Recognizing that the study of many geophysical phenomena in the 200-2000-km range of wavelength is severely hampered by large gaps in the available surface gravity coverage, especially over land, urges all countries to release their land gravity measurements to the scientific community via the International Gravity Bureau; if national interests prevent the release of detailed data, national agencies are requested to release $1^\circ \times 1^\circ$ mean values of free-air gravity anomalies and elevations, which are of fundamental importance for global scientific purposes.

9. Recognizing the high level of accuracy of both absolute and relative gravity measurements recently attained, considering the necessity to adopt standard corrections to gravity observations in order to allow intercomparisons between measurements at different epochs of time, recommends (1) that the tidal correction applied to the gravity observations follow the final recommendations of the Standard Earth Tide Committee as presented at the 18th IUGG General Assembly; (2) that the atmospheric pressure correction refer to a common Standard Atmosphere, the sensitivity coefficient being $-0.315 \text{ mGal hPa}^{-1}$ (C. G. Colborn); and (3) that the gravity gradient correction be published with the adopted local gradient and/or the adopted height difference so that the original values may be recovered.

10. Recognizing that techniques of repeated relative gravity measurement have achieved increased accuracy and have been applied (1) as a sea and land-based tool to detect and investigate gravity changes associated with recent crustal movements, (2) in combination with other techniques such as leveling and VLBI to give a deeper insight into the underlying dynamic processes, and (3) as an element in earthquake prediction research, and noting the success of recent campaigns in various parts of the world, recommends that high priority be given to this research.

11. Recognizing that the physical interpretation of time variations of the natural coordinates, height above sea level, and geographic latitude and longitude requires knowledge of the time variation of the earth's gravity field, and considering that this task can be determined by a world-wide net of gravity stations with repeated precise observations of absolute gravity and height above the current-mean sea level, recommends that efforts be made to observe and reobserve a large number of such stations favorably distributed around the globe.

12. Recognizing the importance of the optimal design of geodetic networks in one, two, or three dimensions, recommends that research in the following fields be encouraged: development of criteria on matrices; investigation of mathematical cost functions reflecting real costs of observing geodetic networks; and realization of operational software.

13. Recognizing the fundamental role of the geodesic boundary value problems in establishing gravity field approximations on a sound theoretical basis as well as in producing quick and stable first order solutions, and noting the progress made in this field, recommends (1) that analysis of fundamental problems such as the Molodtsov problem be pursued to a reasonable conclusion, including nonlinear cases; (2) especially those of colimetry-gravimetry, be investigated with numerical examples to establish the applicability of solutions; and (3) that geodynamic boundary value studies, begun over the last few years, now model the mechanics of planet earth in a unified field theory.

14. Recognizing recent studies of the local mathematical properties of the earth's gravity field using differential methods in such a way that geodesy

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similar implications are included, and considering similar studies in the other associations of IUGG, recommends that these studies be intensified and appropriate interdisciplinary contacts established.

15. Recognizing the importance and feasibility of several kinds of investigations which could lead to major progress in the interdisciplinary field of tidal friction and earth's rotation, (1) that theoretical models of polynoids be computed as narrow time steps as possible (10 million years or smaller for the Phanerozoic, using recent results for continental drift in the Phanerozoic, for appropriate models, and extending, for earlier times, the tidal variability of the tidal torque, with different schematic geometries of the ocean; (2) that despite the dominating role of oceanic tides within the last eons, the rheology of the solid earth be carefully searched for areas in which an "old" earth could differ remarkably from the present earth; and (3) that further geodesic, astronomical, and geological investigations be encouraged in order to enlarge the data base for the study of the earth's rotation.

16. Recognizing the need for the uniform treatment of tidal corrections to various geodesic quantities such as gravity and station positions, and considering the reports of the Standard Earth Tide Committee and SSC 2.55 Predictive Methods for Space Techniques, presented at the 18th General Assembly, recommends that (1) the rigid-earth model be the Cartwright-Tayler-Edden model with additional constants specified by the International Center for Earth Tides, (2) the elastic earth model be that described by Wahr using the 1068 A model earth of Gilbert and Dziewonski, (3) the indirect effect due to the permanent yielding of the earth be removed, and (4) ocean loading effect be calculated using the tidal charts and data produced by Schwiderski as working standards.

17. Recognizing the excellent organization of the Hamburg General Assembly, and the efficient administrative arrangements which made an invaluable contribution to its scientific success, expresses its grateful thanks to its German hosts for their successful efforts in making its meeting so pleasant and scientifically profitable.

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AGU

Actions at Hamburg

International Association of Hydrological Sciences

Symposia

The proceedings of two of the five IAHS symposia at Hamburg were prepublished: *Dissolved Loads of Rivers and Surface Water Quality/Quality Relationships and Hydrology of Humid Tropical Regions with Particular Reference to the Hydrological Effects of Agriculture and Forestry Practice*. These can be purchased from the Office of the Treasurer, 2000 Florida Avenue N.W., Washington DC 20009. The remaining proceedings will be published in 1984.

Resolutions

Reproduced below are resolutions adopted by IAHS during the 18th General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Hamburg, August 15-27, 1983.

The resolutions passed at each quadrennial general assembly of IUGG and of its member associations are an important barometer of current opinion in the geophysics community and can be a powerful tool in the development of the scientific programs to which they are addressed. The resolutions will help advance programs, however, only if they are used. Carried back home by the national committees which make up the IUGG, the resolutions can spread information worldwide on programs that promise to most effectively advance geophysical knowledge. IUGG and its member associations intend that member groups will present the resolutions before their respective bodies and otherwise use them to make decisions and actions of international scientific thought.

The 19 resolutions adopted by IUGG as a whole appeared in *Eos*, October 4, 1983, p. 582.

Resolution 2/1

Appreciating highly the close cooperation with UNESCO and WMO in the framework of the IHP and the OHP, respectively, recommends that the IAHS commissions take active part in the preparation and implementation of the third phase of IHP, continue their participation in the OHP, and ensure through their activities in the international programs the promotion of both the advancement of hydrological sciences and the transfer and dissemination of existing scientific results; and invites the Bureau of IAHS to strengthen the cooperation of the Association with other UN organizations dealing with water problems, such as FAO, WMO, IAEA, UNEP and the regional UN Economic Commissions.

Resolution 2/2

Considering that the future of this Association rests in the active participation of young hydrologists in its affairs, instructs the Bureau to establish from amongst young hydrologists a Working Group in cooperation with UNESCO and WMO to consider and report on the prospects for hydrology in the years leading to the 21st century, and further instructs the Bureau to recognize the scientific contributions of a young hydrologist by making an annual monetary award to be known as the "Tison Award" on the basis of a paper published in the *Hydrological Science Journal* or in the *Proceedings of a symposium* published by the Association.

The following comments are from Secretary General Rodda:

The Working Group referred to in Resolution 2/2, the so called Hydrology 2000 Working Group, consists of the following members: D. N. Collins (UK), S. I. Haswain (Libya), L. T. Gottschalk (Sweden), Z. Kundzewicz (Poland), A. Szollosi-Nagy (Hungary), E. D. Andrews (USA), B. Webb (UK), and A. Florida (People's Republic of Benin). A small subcommittee was formed to consider the exact terms of the Tison Award. It consists of I. Rodriguez-Iturbe, A. I. Johnson, and T. O'Donnell.

A third resolution was concerned with strengthening the position of hydrologists and IAHS within IUGG. In the past, few of the IUGG officers have been hydrologists, and currently none of the members of the IUGG council, which is composed largely of chairmen of IUGG national committees, is a hydrologist. The same applies to several of the other disciplines represented in IUGG. This resolution was discussed by the IAHS Assembly but was withdrawn because of certain difficulties foreseen by delegates from several countries.

New Officers

H. J. Peters reports that a major change was made in the way the officers of the commissions of the association are selected. In the past, nominations for all IAHS officers and all commission officers were submitted to the Nominating Committee, which prepared a slate of nominees presented to the plenary session.

Under the new system, agreed upon at Exeter in 1982, ratified at the plenary session on August 15, 1983, and used, for the first time, at the Hamburg assembly, commission officers are elected at the individual plenary meetings of the commissions and these elections are not subject to review or ratification by the IAHS plenary meeting.

This change is expected to produce improved continuity of officers and greater autonomy for the commissions. The IAHS Nominating Committee reviewed the commissions' slates of nominees prior to announcements to assure geographical balance in the IAHS as a whole.

There were several female nominees for association and commission offices but none were among those presented by the Nominating Committee. Mark Meier, outgoing IAHS president, remarked that women had not been included and said he hoped that in the future he would be able to address the IAHS Bureau as "Ladies and Gentlemen."

The following IAHS officers were elected for 1985-1987 during the administrative sessions at Hamburg. They are G. Kovacs, president; I. Rodriguez-Iturbe, first vice president; V. M. Koliakou, second vice president; N. B. Ayibotele, third vice president; J. C. Rodda, secretary general; H. C. Riggs, treasurer; and T. O'Donnell, editor.

The following commission and committee presidents and secretaries were elected: International Commission on Continental Erosion D. E. Walling president and R. F. Hildreth secretary. International Commission on Groundwater H. J. Goleibander president and S. M. Gorelick secretary. International Commission of Snow and Ice L. Lilliboury president and C. W. Winkler secretary. International Commission on Surface Water H. Liebscher president and A. Szollosi-Nagy secretary. International Commission on Water Quality G. Matthes president and D. Rickert secretary. International Commission on Water Resource Systems M. Hamlin president and L. T. Gottschalk secretary. International Committee on Remote Sensing and Data Transmission A. I. Johnson president and B. E. Goodison secretary.

International Association of Geodesy

Overview

The International Association of Geodesy program at the 18th General Assembly of IUGG featured six special symposia: "The Role of Gravimetry in Geodynamics," "Geodynamic Aspects of the Earth's Rotation," "Improved Gravity Field Estimates on a Global Basis," "Geodesic Reference Systems," "Strategies for Solving Geodesic Problems in Developing Countries," and "The Future of Terrestrial and Space Methods for Positioning." The papers are expected to be published as symposia proceedings by the Department of Geodesic Science and Surveying, Ohio State University, early in 1984.

An active and exciting subject area is the study of earth rotation. Advanced observational techniques are routinely producing polar motion and UT1 determinations having temporal and spatial resolutions three to ten times better than the classical optical observations used by the International Polar Motion Service and the Bureau International de l'Heure. The National Geodetic Survey/NASA POLARIS results are widely recognized as the best available and are used as the "standard" to which other results are to be compared. Studies of the atmosphere's (wind and pressure) role in polar motion and variations in the spin rate are the center of attention. Presentations on this subject were quite convincing relative to the dominance of the mechanism. A special study group was established under the presidency of Jean Dickey, Jet Propulsion Laboratory, to focus on this issue, and two of the IUGG resolutions (*Eos*, October 4, 1983, p. 582) pertain to this issue.

Another interesting highlight was the presentation by Bernd Richter, Institut für Angewandte Geodäsie, on "Tide Spectrum." It appears that the cryogenic gravity meter record there contains a clear signature of polar motion; Richter only compared the record to the IHP polar motion series, but a very preliminary look at the structure in the residuals suggests that the gravity meter may have detected smaller-scale polar motion features.



Talking at the exhibit area of the 18th General Assembly of IUGG in Hamburg last August were (left to right) George D. Garland, president of IUGG; H. J. Dierbaum, acting chairman, FRG National Committee for Geodesy and Geophysics; and A. F. Spillman, executive director of AGU.



Enjoying a social hour at Hamburg's Rathaus during the IUGG General Assembly last August were Penny Kissinger (wife of AGU Foreign Secretary and IUGG Bureau Member Carl Kissinger) and Keith Cole, President of IAGA.

observed by the more advanced techniques, i.e., VLBI and SLR.

It has been a truism that at previous IUGG General Assemblies the European geodesists concentrated on theory, while Americans emphasized new technology. In general, this separation now seems to be much less pronounced. There is a much closer community of interests among these groups compared to years ago. The interest of Europeans in Very Long Baseline Interferometry, Global Positioning Systems, etc. is now very strong, and they are eager to apply these new methods, developed in the U.S., as efficiently as possible.

In the same vein, whereas at previous general assemblies the role of countries other than those in North America or Europe was negligible, other parts of the world, especially Japan and China, are proving themselves prominent participants in the geodesic community. The so-called developing countries are also asserting quite loudly their requirements (e.g., African Doppler Survey). All this means that international cooperation is more important than ever in sharing resources and information; both at individual and organizational levels.

A major problem at the meeting was that the amount of business transacted was so great that a participant, despite a 14-hour day, could absorb only a small fraction of the available program. There were numerous pre-session sessions that attendees missed. First-time attendees discovered that geodesy is a branch of science which is much more popular outside the U.S. than within. Three U.S. representatives were elected to

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